**Amendments to the Specification**

Please replace the **Title** of the Application with the following amended Title:

"Golf Club Head"

Please replace the paragraphs starting on **page 1, line 5** and ending on **page 1, line 13** with the following amended paragraphs:

Background of the Invention

Field of the Invention

The present invention relates to golf clubs, and, in particular, to a ~~wood-type~~ golf club head with ~~high inertia~~ a designated relationship between the volume of the club head and the rotational inertia of the club head about a particular axis.

Description of the Related Art

A wood-type golf club typically includes a hollow shaft with a golf club head attached to the lower end of the shaft. The club head typically includes a load-bearing outer shell with an integral or attached strike plate. The strike plate defines a ~~substantially planar~~ front surface or strike face adapted for striking a golf ball.

Please replace the paragraphs starting on **page 1, line 20** and ending on **page 2, line 5** with the following amended paragraphs:

For some time, golf club manufacturers have searched for ways to best distribute the performance ~~weight~~ mass so as to improve club head performance. Recently, golf club ~~manufactures~~ manufacturers have attempted to position most of the performance mass along the perimeter of the club head so as to increase the rotational moment of inertia ("MOI") of the club head about the club head center of gravity ("CG"). In particular, many club heads include two or more weights spaced along the heel/toe axis (i.e., an axis that extends through the club head CG generally parallel to the strike face in a generally horizontal direction relative to the ground when the club head is at address position). Such perimeter weighting increases the ~~inertia~~ MOI of the club

head about the vertical axis <u>(i.e., an axis that extends through the club head CG in a generally vertical direction relative to the ground when the club head is at address position)</u>. This tends to make the club head more resistant to twisting during off-center hits. However, as will be explained below, such perimeter weighting represents an inefficient use of the performance mass.

An exception to the general trend of heel/toe weighting is U.S. Patent No. 5,176,383, which discloses <u>a</u> club head with a weight positioned at the rear of a support. The support and the weight are in-line with the center of percussion of the club head. This patent claims that this arrangement concentrates the inertial energy of the club head along the center of percussion, which, in turn, maximizes the amount of energy that is imparted to the golf ball. However, a golf club according to this patent disadvantageously has a ~~center of gravity~~ <u>CG</u> that is above the horizontal centerline of the golf club.

<u>Please delete the paragraphs starting on page 2, line 5 and ending on page 3, line 2.</u>

<u>Please replace the paragraph starting on page 3, line 26 and ending on page 3, line 26 with the following amended paragraph</u>:

Figure 1 is a front view of a golf club <u>head</u> centered about a coordinate system;

<u>Please replace the paragraphs starting on page 4, line 8 and ending on page 11, line 16 with the following amended paragraphs</u>:

Figure 1 is a perspective view of a club head 10 located about a coordinate system 12. The coordinate system 12 is centered about the center of ~~mass~~ <u>gravity ("CG")</u> of the club head. As is typical in the art, the club head 10 comprises a strike plate 14, which defines a ~~substantially planar~~ front surface or strike face 16 for impacting a golf ball. A hosel 18 extends upwardly from the strike plate 14. The hosel 18 is used to attach the club head 10 to a golf club shaft (not shown) as is well known in the art. The club head 10 also includes a load bearing outer shell 20 that is either integrally made with or attached to the strike plate 14. A heel region 22 of the club head <u>10</u> is located close to the hosel 18 while the toe region 24 of the club head is located opposite the heel region 22.

The coordinate system 12 comprises three axes: (i) a vertical axis 26 that extends through the CG ~~in a vertical direction and lies~~ generally parallel to the strike face 16 in a generally vertical direction relative to the ground when the club head 10 is at address position, (ii) a heel/toe axis 28 that extends through the CG ~~in a horizontal direction and lies~~ generally parallel to the strike face 16 and generally perpendicular to the vertical axis 26, and (iii) a front/back axis 30 that extends through the CG ~~in a horizontal direction and lies~~ generally perpendicular to the vertical axis 26 and the heel/toe axis 28. Heel/toe axis 28 and front/back axis 30 both extend in a generally horizontal direction relative to the ground when the club head 10 is at address position.

The club head 10 has a rotational moment of inertia (i.e., a resistance to twisting) about each of the three axes. Specifically, the club head 10 has a moment of inertia ("Izz") about the vertical axis 26 ~~("Izz")~~, a moment of inertia ("Ixx") about the heel/toe axis 28 ~~("Iyy")~~, and a moment of inertia ("Iyy") about the front/back axis 30 ~~("Ixx")~~. The methods for determining these moments of inertia for any particular club head are well known to those skilled in the art.

An aspect of Applicant's invention is the realization that preferably most or more preferably all of the performance mass of the club head 10 should be arranged so as to increase the moment of inertia Ixx about the heel/toe axis 28 and the moment of inertia Izz about the vertical axis 26. Figure 2 is a top plan view of a golf ball 32 hitting the strike face 16 of a club head 10. As is not unusual in golf, the club head 10 is shown striking the golf ball 32 "off-center". In this case, the golf ball 32 has hit the club head 10 near the toe 24 of the club head (i.e., a "side off-center hit"). The side off-center ~~side~~ hit causes the club head 10 to twist about the vertical axis 26 as shown by arrow 27A. This tends to produce an inaccurate shot.

To mitigate the twisting about the vertical axis 26 during such side off-center ~~side~~ hits, golf club manufacturers have typically sought to increase the golf club's moment of inertia Izz about the vertical axis 26 by concentrating at least some of the performance weight along the heel/toe axis 28. For example, heel/toe weights, which are indicated by the reference number 25, can be added to the club head 10 to increase the club head's moment of inertia Izz about the vertical axis 26. This produces more accurate shots.

However, ~~Applicant realized that~~ such heel/toe weights 25 do not necessarily improve performance during all off-center hits. For example, Figure 3 is a side view of the club head 10 striking a golf ball 32. As with Figure 2, the club head 10 has struck the golf ball 32 off-center. However, in this case, the golf ball 32 has hit the club head 10 below the center of the club head

(i.e., a "vertical off-center hit"). This type of off-center hit causes the club head 10 to twist about the heel/toe axis 28 as indicated by arrow 27B. However, heel/toe weights 25 do not increase the club head's moment of inertia Ixx about the heel/toe axis 28. Thus, they do not reduce the tendency of the club head 10 to twist about the heel/toe axis 28. Accordingly, heel/toe weights 25 do not improve the golf club's performance during vertical off-center hits. Heel/toe weights 25 do increase the club head's moment of inertia Iyy about the front/back axis 30. However, ~~Applicant~~ it has been determined that during off-center hits the ~~golf~~ club head 10 tends not to rotate about this axis. Accordingly, the moment of inertia Iyy about the front/back axis 30 is not as effective in improving club head performance.

In contrast, ~~the Applicant recognized that~~ front/back weights 29, which are spaced substantially about the front/back axis 30, increase the club head's moment of inertia Ixx about the heel/toe axis 28. Thus, front/back weights 29 improve the golf club's performance during vertical off-center hits. Moreover, as shown in Figure 2, such front/back weights 29 also increase the club head's moment of inertia Izz about the vertical axis 26. Therefore, front/back weights 29 improve the club head's performance during side off-center hits and vertical off-center hits.

Another aspect of ~~Applicant's~~ the invention is the recognition that the performance mass of the club head 10 should also be arranged such that the club head has a low ~~center of gravity~~ CG. More specifically, as shown in Figure 4, the ~~center of gravity~~ CG of the club head 10 is preferably located below a horizontal centerline 31 of the club head ~~10~~ (i.e., the line 31 that extends through the geometric center of the strike face 16 and bisects a ~~second~~ vertical line 33, which extends perpendicularly from the ground 35 to the top of the ~~club~~ strike face 16 when the club head 10 is in the normal address position). Consequently, in some embodiments the performance mass is concentrated below the physical center of the club head. In contrast, most golf clubs have a ~~center of gravity~~ CG above the horizontal centerline 31.

The vertical distance between the ~~center of gravity~~ CG and the horizontal centerline 31 will be referred to as CGz. As mentioned above, a club head 10 desirably has a ~~center of gravity~~ CG that lies below the horizontal centerline 31, which extends through the geometric center ~~37~~ of the strike face 16. Preferably, the ~~center of gravity~~ CG lies at least 1 millimeter below the horizontal centerline 31 (i.e., CGz is at least 1 mm). More preferably, CGz is at least 2 millimeters. It is difficult to design wood-type clubs with a ~~center of gravity~~ CG below the horizontal centerline 31. Accordingly, the front/back weights 29 of the club head 10 preferably

are located entirely below the horizontal center line 31 of the club head. Moreover, moving the CG even a small distance below the horizontal centerline 31 has a large effect on the golf shot. For example, failure to get the golf ball air borne results in drastically reduced shot distance. A low ~~center of gravity~~ CG helps the golfer get a golf ball air borne. Specifically, a lower ~~center of gravity~~ CG increases the launch angle of a golf shot because when the ~~center of gravity~~ CG is below the point of impact the ~~club~~ strike face 16 rotates in such away that it increases the loft of the golf ~~ball~~ club.

The club head 10 preferably should also be arranged such that the ~~center of gravity~~ CG is located not too far back from a shaft or hosel axis 37 of the club head ~~10~~ (i.e., a line that extends axially through the center of the shaft and the hosel). The horizontal distance measured in a direction back from the strike face 16 between the ~~center of gravity~~ CG and the ~~shaft or~~ hosel axis 37 will be referred to as Delta 1. Preferably, Delta 1 is in the range of 12 - 25 millimeters. More preferably, Delta 1 is in the range of 16-20 millimeters. Most preferably, Delta 1 is in the range of 17 -18 millimeters. Delta 1 can be manipulated by varying the mass in front of the ~~center of gravity~~ CG (i.e., closer to the face) with respect to the mass behind the ~~center of gravity~~ CG. That is, by increasing the mass behind the ~~center of gravity~~ CG with respect to the mass in front of the ~~center of gravity~~ CG, Delta 1 can be increased. In a similar manner, by increasing the mass in front of the ~~center of gravity~~ CG with respect to the mass behind the ~~center of gravity~~ CG Delta 1 can be decreased. The above ranges for Delta 1 are preferred for several reasons. If Delta 1 is too far forward, the trajectory of the golf ball tends to be too low and to the right, especially in large club heads (e.g., ~~an interior value~~ club heads having a head volume greater than 300 ~~centimeters cubed~~ $cm^3$). Conversely, if Delta 1 is too far back the trajectory of the golf ball tends to be too high and the golf ball tends to have too much spin.

With reference now to Figures 5-8 a preferred construction of a golf club head 50 with certain features and advantages according to the present invention will now be described. As shown in Figure 5, the club head 50 is comprised of a strike plate 58. The strike plate 58 defines a ~~substantially planar~~ front surface or strike face 60 for impacting a golf ball. A hosel 62 extends upwardly from the strike plate 58. The hosel 62 is configured to be coupled to a golf club shaft (not shown) in a well known manner. The strike plate 58 and hosel 62 are preferably made of a strong yet light weight metal, such as titanium or a composite material. Of course, other suitable materials can be used.

The club head 50 further comprises a load bearing outer shell 64 that is preferably attached to the strike plate 58. As with the strike plate 58, the outer shell is preferably made of a strong yet light weight metal, such as, for example, titanium or a composite material. Of course, other suitable materials can be used. The outer shell 64 preferably defines an interior ~~volume~~ cavity 65 (see Figure 7) ~~of~~ within the club head 50. Together the strike plate 58 and the outer shell 64 define a head volume (i.e., "HV") of the club head 50. The head volume HV represents the volume occupied by the club head 50 and is traditionally measured in $cm^3$ ~~cubic centimeters (i.e., "cc")~~. Head volume is an important design parameter. Other things being equal, it is easier to achieve a higher rotational moment of inertia about the CG in a club head that defines a larger head volume as compared to a club head that defines a smaller head volume. This is because the performance weight can be distributed farther from the ~~center of club~~ CG in a club head with a large head volume. Conversely, other things being equal, it is easier to achieve a lower ~~center of gravity~~ CG in a club head with a small head volume as compared to a club head with a large head volume. Accordingly, a design compromise must be made between desired inertial characteristics of the club head and the location of the CG. Moreover, golfers generally do not like the look and feel of unusually large or small club heads. Thus, the head volume ~~65~~ of the club head 50 preferably is between 200 - 450 ~~cubic centimeters~~ $cm^3$.

With reference to ~~the front view of~~ Figure 6, the club head 50 includes a toe region 66 and a heel region 68, as will be known to those of skill in the art. The bottom of the club head 50 is delimited in part by a sole 70 and the top of the club head is delimited by a crown 72. The features of the club head 50 described up to this point can be considered conventional.

Golfers prefer a driver type golf club to have a total mass of less than 250 grams. Therefore, the club head 50 preferably has a total mass of less than 250 grams. More preferably, the club head 50 has a total mass of less than 230 grams. Most preferably, the club head 50 has a total mass of less than 210 grams. A lighter club head 50 is preferred because it reduces the swing weight of the golf club. However, a lighter club head 50 also has less performance ~~weight~~ mass available to increase the ~~moment of~~ rotational inertia of the club head 50 about the club head CG. Thus, a design compromise must be made between the total mass of the club head 50 and the desired ~~inertial~~ rotational inertia characteristics of the club head.

The structural members (i.e., the outer shell 64 and the strike plate 58) ~~have mass of~~ comprise approximately 60% - 90% of the total mass of the club head 50. The remaining 40% -

10% of the club head mass constitutes the performance mass, which is preferably distributed in ~~the~~ weight plugs <u>or weights</u> 74 described below.

Figures 7 and 8 show cross-sectional side and bottom views, respectively, of the club head 50. In the preferred embodiment, the golf club head 50 includes two or more weights <u>or</u> plugs 74a, 74b that are situated within corresponding recesses 76a, 76b formed in the outer shell 64. In the illustrated embodiment, the weights ~~74~~ <u>74a, 74b</u> are removably coupled to the sole 70 of the club head 50 by screws 78. However, it should be appreciated that the weights 74a, 74b can be coupled to the club head 50 by using an adhesive, brazing, etc., or the weights ~~74~~ may be integrally formed with the sole ~~plate~~ <u>70</u>. The weights 74a, 74b preferably are made of a material, such as, for example, tungsten, that is denser than the material(s) that form the outer shell 64 and the strike plate 58.

As best seen in Figure 8, the weights 74a, 74b are preferably located along a front/back axis 80 that extends generally perpendicularly away from the strike face 60 of the club head 50. More preferably, one of the weights 74a is located along the front back axis 80 near the strike plate 58 and the other weight 74b is also located along the front back axis 80 near a rear end 81 of the club head 50.

In addition, as best seen in Figure 7, both of the weights 74a, 74b are preferably ~~also~~ located below the horizontal centerline 82 of the club head 50. This arrangement is preferred because it moves the ~~center of gravity~~ <u>CG</u> of the club head 50 to a position below the horizontal centerline 82.

The club head 50 described above preferably has a moment of inertia <u>Ixx</u> about the heel/toe axis <u>28</u> that is significantly greater than conventional club heads (i.e., interior volumes between 200-350 ~~centimeters cubed~~ <u>cm³</u> and a mass between 180-250 grams). As mentioned above, the inertial properties of a club head are dependent upon the head volume. Accordingly, the club head 50 preferably has a moment of inertia <u>Ixx</u> ~~through~~ <u>about</u> the ~~center of gravity about the~~ heel/toe axis <u>28</u> as set forth below in equation 1.

$$\cancel{I_{yy}}\ \underline{I_{xx}} \geq .46 * HV + 77 \qquad (1)$$

where: HV [=] <u>is club head volume in units of cm³</u> ~~cubic centimeters (cc)~~
[Iyy =] <u>Ixx is in units of kg-mm²</u> ~~kilogram millimeters squared (kg-mm²)~~

More preferably, the club head 50 has a moment of inertia ~~through~~ Ixx about the ~~center of gravity about the~~ heel/toe axis 28 ~~is~~ as set forth below in equation 2.

$$\cancel{Iyy}\ \underline{Ixx} \geq .46 * HV + 107 \qquad (2)$$

where: HV ~~[=]~~ is club head volume in units of $cm^3$ ~~cubic centimeters (cc)~~
[Iyy =] Ixx is in units of $kg\text{-}mm^2$ ~~kilogram-millimeters squared ($kg\text{-}mm^2$)~~

The higher moments of inertia Ixx of equation 2 can be achieved by reducing or holding constant the mass of the shell 64 and/or the strike plate 58 while increasing or holding constant the mass of the weights 74a, 74b while also giving due consideration to the structural integrity of the club head 50.

In addition, the ~~center of gravity~~ CG of the club head 50 preferably lies below the horizontal centerline 82 of the club head 50. More preferably, the ~~center of gravity~~ CG is ~~greater~~ more than 1 ~~millimeter~~ mm below the horizontal centerline 82 of the club head 50. The lower ~~center of gravity~~ CG can be achieved by increasing the mass of the weights 74a, 74b while reducing or holding constant the mass of the shell 64 and strike plate 58. The ~~center of gravity~~ CG can also be reduced by decreasing the thickness of the weights 74a, 74b and/or decreasing the density of the weights 74a, 74b.

Preferably, the club head 50 also has a moment of inertia Izz about the vertical axis 26 that is at least 250 ~~kilograms millimeter squared~~ $kg\text{-}mm^2$. More preferably, the club head has a moment of inertia Izz about the vertical axis 26 of at least 300 ~~kilograms millimeter squared~~ $kg\text{-}mm^2$. As with the moment of inertia Ixx about the heel/toe axis 28, the moment of inertia Izz about the vertical axis 26 can be increased by reducing or holding constant the mass of the shell 64 and/or the strike plate 58 while increasing or holding constant the mass of the weights 74 while also giving due consideration to the structural integrity of the club head 50.

As mentioned above, the Delta 1 of the club head 50 preferably is less than 30 ~~millimeters~~ mm. Preferably, Delta 1 is in the range of 12 - 25 ~~millimeters~~ mm. More preferably, Delta 1 is in the range of 16-20 ~~millimeters~~ mm. Most preferably, Delta 1 is in the range of 17 -18 ~~millimeters~~ mm.

The club head 50 described above has generally traditional dimensions as a driver-type wood (i.e., the head volume is between ~~300~~ 200 and ~~200~~ 300 ~~centimeters cubed~~ $cm^3$). However, some golfers prefer a "large" club head. That is, some golfers prefer a club head that defines an interior volume greater than 300 ~~centimeters cubed~~ $cm^3$ and a mass between about 180-210 grams. If such a club head is desired, it can be constructed as described above by enlarging the size of the strike plate 58 and the outer shell 64.

As with the club head 50 described above, the club head ~~50~~ preferably has a moment of inertia Ixx about the heel/toe axis 28 as set forth above in equation 1. More preferably, the club head 50 has a moment of inertia Ixx about the heel/toe axis 28 as set forth in equation 2. The ~~center of gravity~~ CG of the club head 50 also preferably lies below the horizontal centerline 82 of the club head ~~50~~. More preferably, the ~~center of gravity~~ CG is ~~greater~~ more than 1 ~~millimeters~~ mm below the horizontal centerline 82 of the club head 50. Preferably, the club head 50 also has a moment of inertia Izz about the vertical axis 26 that is at least 250 ~~kilogram millimeters squared (kg-mm²)~~ kg-mm². More preferably, the club head has a moment of inertia Izz about the vertical axis 26 of at least 300 ~~kilogram millimeters squared (kg-mm²)~~ kg-mm². Preferably, Delta 1 is in the range of 12 - 25 ~~millimeters~~ mm. More preferably, Delta 1 is in the range of 16-20 ~~millimeters~~ mm. Most preferably, Delta 1 is in the range of 17 -18 ~~millimeters~~ mm.

In a modified arrangement, the club head 50 may comprise a smaller driver or a fairway wood club head. This smaller club head defines ~~an interior~~ a head volume of less than 200 ~~centimeters cubed~~ $cm^3$ and a mass between about 200-250 grams. If such a club head 50 is desired, it also can be constructed as described above by adjusting the shape and size of the strike plate 58 and the outer shell 64. As with the club head 50 described above, ~~the~~ a smaller driver or fairway wood type club head ~~50~~ preferably has a moment of inertia Ixx about the heel/toe axis 28 as set forth above in equation 1. More preferably, the club head 50 has a moment of inertia Ixx about the heel/toe axis 28 as set forth in equation 2. The ~~center of gravity~~ CG of the club head 50 also preferably lies at least 1 ~~millimeter~~ mm below the horizontal centerline 82 of the club head 50. More preferably, the ~~center of gravity~~ CG is ~~greater~~ more than 2 ~~millimeter~~ mm below the horizontal centerline 82 of the club head 50. Preferably, the club head 50 also has a moment of inertia Izz about the vertical axis 26 that is at least 200 ~~kilogram millimeters squared (kg-mm²)~~ kg-mm². More preferably, the club head 50 has a moment of inertia Izz about the vertical axis 26 of at least 250 ~~kilogram millimeters squared (kg-mm²)~~ kg-mm². Delta 1 preferably is in the range of 12 -

25 ~~millimeters~~ mm. More preferably, Delta 1 is in the range of 16-20 ~~millimeters~~ mm. Most preferably, Delta 1 is in the range of 17 -18 ~~millimeters~~ mm.

Please replace the Abstract starting on page 16, line 2 and ending on page 16, line 11 with the following amended Abstract:

A club head for a golf club comprises a strike face and an outer shell. The strike face and the outer shell define a head volume of the club head. The club head has a first axis that extends generally horizontally and parallel to the strike face, a first moment of inertia about the first axis, a second axis that lies generally vertically and perpendicular to the first axis, a second moment of inertia about the second axis, and a center of gravity lying below a horizontal centerline of the club head. The first moment of inertia in units of kg-mm$^2$ is greater than or equal to approximately 77 plus 0.46 times the head volume in units of cm$^3$.